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is a liquid bath, consisting of magnetic ferrous oxide suspended in spindle oil in proportion of 25-35 g of powder for 1000 cc of liquid.

The acceptable number of hair cracks on the surface of a stepped specimen is as follows:

Total number of hair cracks	4-5
Maximum length of hair cracks	5-6 mm
Total length of hair cracks	20-25 mm
Maximum number of cracks on each step of a specimen	3
Total length of cracks on a single step	10 mm

Every vane in finished form is also subjected to magnetic particle inspection. According to the results of inspection all vanes are divided into four groups.

Group I. The number of hairline cracks on the outer surface of vanes are not greater than 3, and they are located separately from each other being not over 10 mm in length.

Group II. a) The number of cracks 3 or less, if even one of cracks is longer than 10 mm; b) the number of cracks 6 or less, each crack not longer than 10 mm.

Group III. a) The number of cracks 6 or less, if any of cracks is longer than 10 mm; b) the number of cracks 10 or less, each crack not over 10 mm in length.

Group IV. a) Occurrence of a single crack over 20 mm in length; b) concentrations of small cracks or occurrence of cracks after each other along entire length of a vane; c) more than 12 cracks of any length.

The vanes of group I are accepted for assembling, the vanes of groups II and III are sent for elimination of detected defects by additional grinding and returned for magnetic particle inspection. Group IV is rejected entirely.

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For investigating the effect of hairline cracks on the mechanical properties of metal, two billets of stainless steel were used. They were taken from two different heats, one of which was considered acceptable in respect to hairline cracks (heat A) and the second -- rejectable (heat B).

Results of chemical analyses are as follows:

Heat	Part of billet from which sample was taken	C%	Si%	Mn%	S%	P%	Cr%	Ni%
A	Outer layer	0.16	0.44	0.30	0.017	0.022	13.8	0.20
	Central zone	0.15	0.43	0.33	0.015	0.026	13.7	0.20
B	Outer layer	0.16	0.08	0.40	0.020	0.028	13.7	0.20
	Central zone	0.15	0.12	0.43	0.020	0.030	13.7	0.20

Both heats were heat treated simultaneously: heated to 1020-1030°, cooled in air, tempered at 720-730° for 1.5-2 hours, cooled in air.

Analysis of results of mechanical tests shows that the strength and plasticity of both heats are the same for longitudinal specimens. In case of transversal specimens heat B (contaminated with hair cracks) revealed lower plasticity.

The impact strength of heat B is higher in both, longitudinal and transversal, directions. Such an effect of hairline cracks on impact strength may be explained by the fact that in dynamic tests the hairline cracks deviate a destruction fracture from the rectilinear direction; thus increasing the impact strength. It was impossible to make a specimen in such a way that the hairline cracks were located exactly in the plane of fracture.

For evaluating the capacity of metal for local plastic deformations tests for 180° cold bending were conducted on longitudinal and transverse specimens. Only the transverse specimens of heat B gave unsatisfactory results in the form of tears on the surface under tension.

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Results of fatigue tests demonstrated that both heats have practically similar fatigue limits. The direction of cutting the specimen has a considerably greater effect than the presence of hairline cracks.

#### Corrosion test

After keeping the specimens for 48 hours in two percent solution of hydrochloric acid the hairline cracks developed into long and wide cracks. The same effect was revealed after electrolytic polishing and under action of Nishien reagent. But action of steam revealed no corrosion centers near hairline cracks.

#### Influence of forging

Billets of 90 x 45 mm section were rolled being reduced in area of cross-section by 30 and 60%. Two stepped specimens were made from each of the reduced billets. After etching the hair cracks were counted. Results are given in following table.

<u>State of metal</u>	<u>Number and size of hair cracks</u>
Initial	4 large cracks, many small ones
30% reduced	3 large cracks, 8 medium, many small ones
	3 large cracks, 5 medium, many small
60% reduced	1 large crack, 4 medium, many small cracks
	1 large crack, 2 medium, very many small cracks

The general impression: in additional forging the hair cracks are not welded but are broken into smaller cracks.

#### Microscopic analysis

The character of hair cracks is the same in all cases. Hair cracks represent chains of nonmetallic inclusions, hard and brittle, as is indicated by the equiaxial property of separate inclusions.

Only in billets with an extremely great number of hairline cracks were the inclusions, considerably elongated in the direction of rolling, observed. In these cases partial or complete crumbling of the nonmetallic substance was noticed.

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In ferritic chrome steels the hairline cracks, as a rule, are present in ferrite and in martensitic steels, they are observed in sorbite of somewhat lighter color than other areas of sorbite. Evidently, in the process of steel crystallization the hairline cracks serve as crystallization centers for precipitating crystals of solid solutions.

The depth of separate cracks varies from 0.01 to 0.2 mm. In the process of electric polishing the edges of hairline cracks are sometimes smoothed and, upon completion of the process, the cracks appear on a metal surface as very shallow grooves with a shiny bottom surface.

#### Conclusions

1. The hair cracks represent strings of nonmetallic inclusions which are elongated in the direction of metal deformation causing tears of a surface under strokes of the edges of cutting tools.
2. The hairline cracks have no effect on strength or plasticity of stainless steel if their direction is coincident with the direction of forces acting in a test.
3. The hairline cracks reduce capacity for plastic deformations if their direction is perpendicular to acting forces.
4. No effect of hairline cracks on the fatigue limit of stainless steel was revealed in tests on round specimens.
5. Reduction of metal, contaminated with hairline cracks to smaller cross-section, does not promote fusing of hair cracks.
6. The magnetic particle inspection of materials for manufacturing turbine vanes and finished products is a dependable and efficient method of quality control.

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